Cerebral Vascular Diseases

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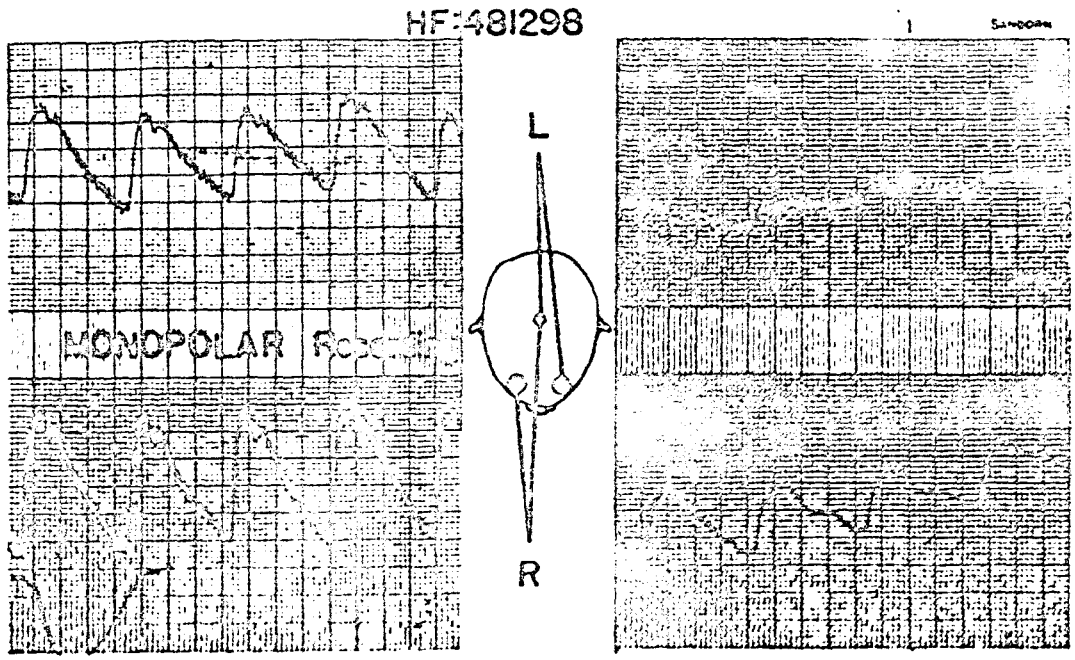

Fig. 12.

CHAIRMAN MILLIKAN: The discussion will be opened by Dr. Ziemnowicz.

DR. ZIEMNOWICZ: It was a pleasure to read the paper of Dr. Markovich on technical fundamentals and technic of rheoencephalography (REG). When I began the evaluation of this method in 1960, there had been no studies in this country on the physical, experimental, and clinical aspects of REG. At the Fifth International Conference on Medical Electronics in July 1963 at Liege, Belgium, a roundtable conference was organized. As chairman of that meeting I expressed my opinion on the current state of rheoencephalography.

The Present Status of Standard and Regional Rheoencephalography (REG)

In search of a method permitting continuous, repetitive, and safe monitoring of circulatory dynamics in the brain, the electric impedance plethysmography, also called rheography, has been applied by the author. It is based on a long-known principle that different tissues offer varying resistance to the passage of an electric current. Conductivity for the alternating current was already used 40 years ago in surgery to differentiate between normal and tumor tissue.[3,14] Investigation on living organism disclosed better conductivity when the amount of blood increases in a given tissue volume as it occurs during each arterial pulse wave. Improved instrumentation for generating alternating current for amplification, as well as recording and measurement, permits us to obtain and compare tracings taken simultaneously from two symmetrical areas of circulation. Recordings of arterial blood pulsation from the head require more advanced equipment and trained personnel for correct application and interpretation. Rheoencephalography, as compared with the early stages of the development of electroencephalography, has some similarities. The EEG method requires an elaboration, amplification, and recording of one modality —the bioelectric activity of the brain. The REG also requires amplification and registration technics for the output of a. c. current,

but in addition it has another source of variability—namely, many different outputs applied to the examined head by different apparatuses. Various currents differing in frequency, wave, length, intensity, and so forth, are in use.

The result is obvious: a lack of possibility for comparison of tracings obtained with equipment differing in generating and recording specifications. The electronic industry builds and sells a variety of rheographs or rheoencephalographs. Scientists are discouraged by poor results obtained when using unreliable equipment. A few European papers and one American paper disavowed this method for cerebral circulatory study.

There is obvious need for standards which would give industry proper specifications in order to provide good instruments to the laboratory or hospital for reliable application and interpretation. The efforts for REG standards should be based on well-controlled basic physical and physiological studies and clinical investigation. An international group should present a draft for an agreement on REG instrumentation, and it should present basic rules for REG interpretation. Attempts in this direction were initiated by the author.

Rheoencephalography produces tracings which parallel pulse waves in each cerebral hemisphere. These recordings are taken from a frontoretromastoid placement of electrodes on both sides of the scalp. Hemispherical REG is here called "standard" because it is now widely applied and accepted.[5-9,10]

A review of published up-to-date results demonstrates a frequent use of the REG method for clinical application without adequate calibration, without previous study on models or experimental material. Unfortunately, there have been also attempts to evaluate data obtained when using inadequate instrumentation and improper technic. This may explain some papers on REG with inconclusive results or with the interpretation of cranial rheography as a tracing essentially or mostly extracranial in origin.[20-23]

Our basic and experimental studies will be published in the near future. They indicate that the cerebral blood supply, not the extracranial circulation, is decisive in standard REG derivation. Pericranial and cranial circulation plays a negligible role as compared to the intracranial—namely, cerebral blood flow. This is confirmed by the Kety-Schmidt quantitative studies with extracranial participation in an average of 2.7 per cent of total jugular vein flow.[9,11,16,18] For the majority of investigators, the standard tracing from both hemispheres appears to suffice for cerebral circulatory studies. Very few tried to distinguish between the circulation in the carotid arteries and in the vertebral-basilar system, or between the arterial branches above the circle of Willis. It is impossible to compare the transversal frontal, temporal, or occipital REG with one electrode on each side of the examined area, because distances between the electrodes vary, as do the amount of tissue volume and the circulating blood. The relationship between the tracings can only be vaguely surmised. It must be realized that a deficit in one unilateral region may be concealed by normal or compensatory increased circulation in the opposite side, since the diagonal placement sums the supply of both sides. Consequently, it is very difficult, or even impossible, to compare quantitatively and interpret transverse REG.[4,12,18]

From standard hemispherical REG, it is also difficult or impossible to diagnose a small circulatory deficit or to discover a restricted area of impaired supply, because of the bulk of tissue with normal or increased compensatory arterial flow. It would be of great importance to localize more exactly the site of circulatory impairment and to follow increasing deficit in blood supply, or to observe the development of spontaneous or pharmacologically aided collateral circulation.

During 1961 and 1962, a technic of additional rheographic studies was developed by the author.[19-24] The so-called regional REG consists in bipolar and bilateral simultaneous tracings from silver mesh electrodes The

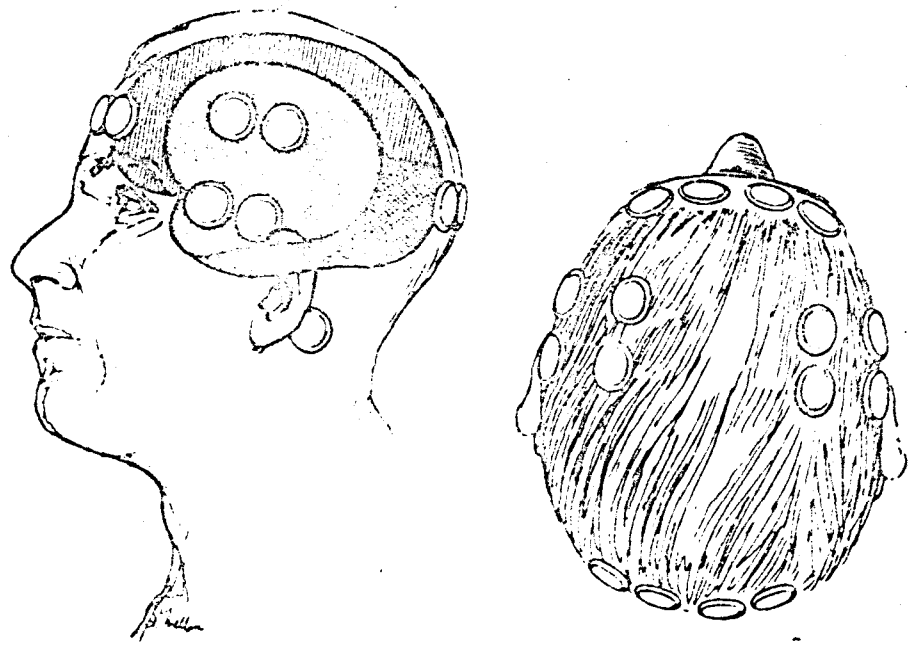

Fig. 13. Placement of electrodes for standard hemispherical REG: frontoretromastoid derivations; and for regional REG (Ziemnowicz): bifrontal, bitemporal, biparietal, and bioccipital. Eye electrodes for rheoophthalmography (ROG) are not shown.

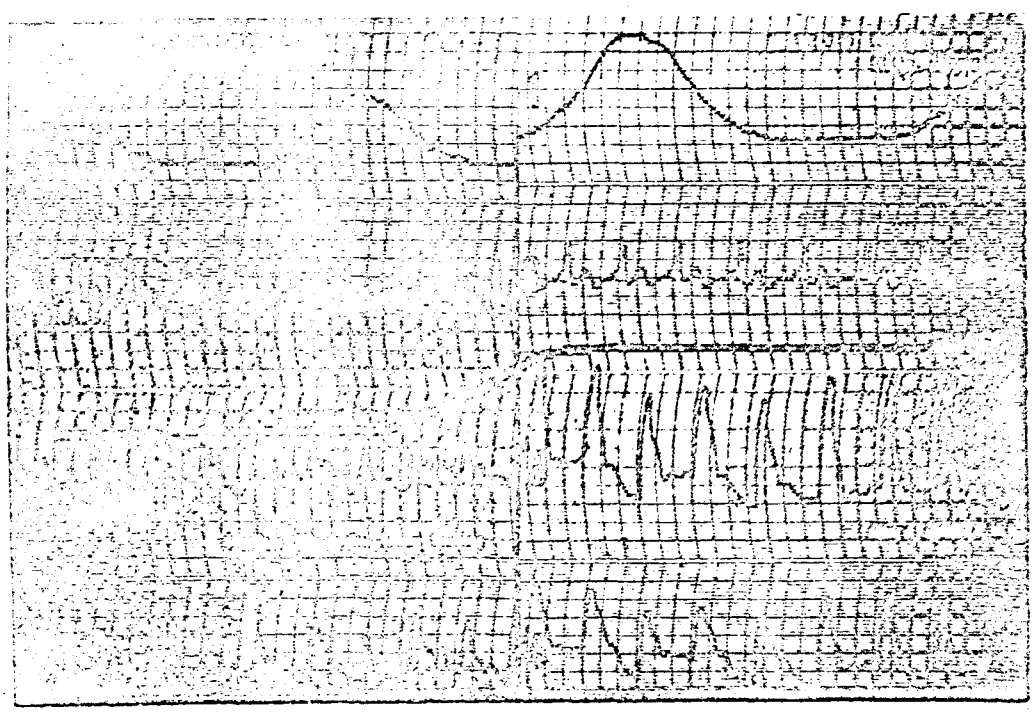

Fig. 14. Normal rheoencephalographic tracings have been disturbed by progressive reduction of amplitude and variation in form. Violent headache followed by interruption of examination. Food intake relieved pain and brought normalization of respiration, heart function, and, finally, cerebral circulation.

following derivations are used: bifrontal, bitemporal, biparietal, and bioccipital. The tracings reflect fluctuations in blood supply in the regions of anterior cerebral arteries, middle cerebral arteries, and the vertebral-basilar system. Standard REG gives a general orientation in the circulation of the left and right internal carotid artery. Regional REG permits us to evaluate the circulatory conditions above the circle of Willis, in the following sequence: frontal lobes (anterior cerebral artery), temporal and parietal lobes (middle cerebral artery), and, finally, occipital lobes (vertebral-basilar arterial system). Our experience during experimental and clinical operations on the brain, and results of clinical cases correlated with additional findings, seem to indicate that the application of standard and regional REG may be of help in more exact diagnosis and prognosis of cerebrovascular diseases and/or conditions which cause circulatory disturbances in the brain.

The technical setup of electrode placement is shown in figure 13. An accessory electrode panel for 24 connections with master switch selector enables us to make a programming with seven runs on six recording channels.

The normal REG is in many respects similar to the extracranial internal carotid artery or to any peripheral rheogram or plethysmogram. However, the cranial rheogram has lower amplitude of pulsations than peripheral tracings, has steeper inclination, and a slightly different form of elevation with two rounded peaks. The above differences between cerebral and peripheral rheograms are due to the rigid walls of the cranial cavity, the existence of intracranial pressure, constant outflow of venous blood, and of incompressible but movable cerebrospinal fluid.

REG tracings taken from the so-called normal individuals indicate that the completely symmetrical REG in all derivations is infrequent. It is more frequent in the first decades of life. This is in accordance with the anatomical asymmetries in carotid, basilar, and circle of Willis systems and in later-life asymmetries, mainly due to arteriosclerotic changes. In this respect, the repeated serial

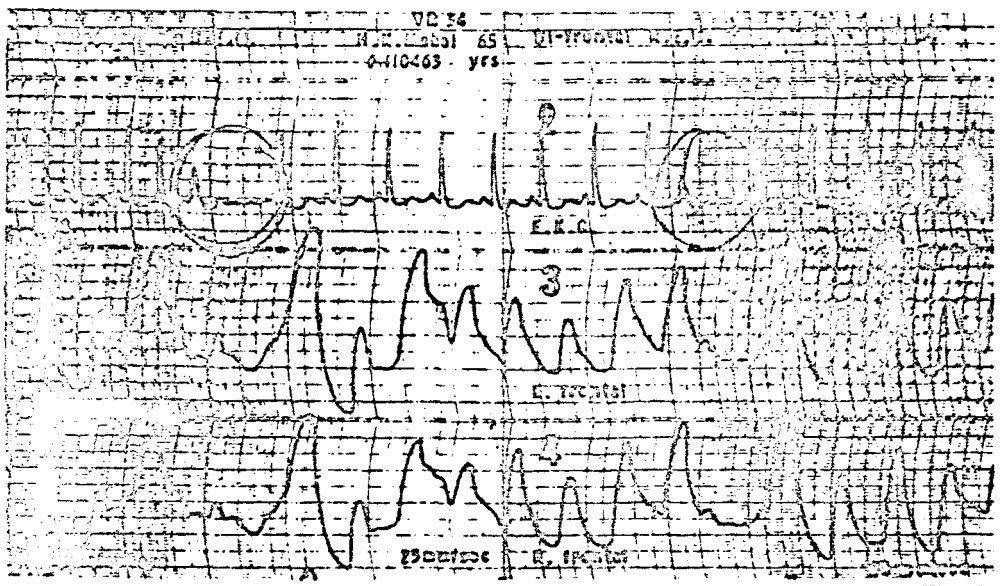

Fig. 13. Cerebral circulatory disturbances related mostly to continuous cardiac arrhythmia. The changes are visible in standard hemispherical and in regional frontal REG derivations.

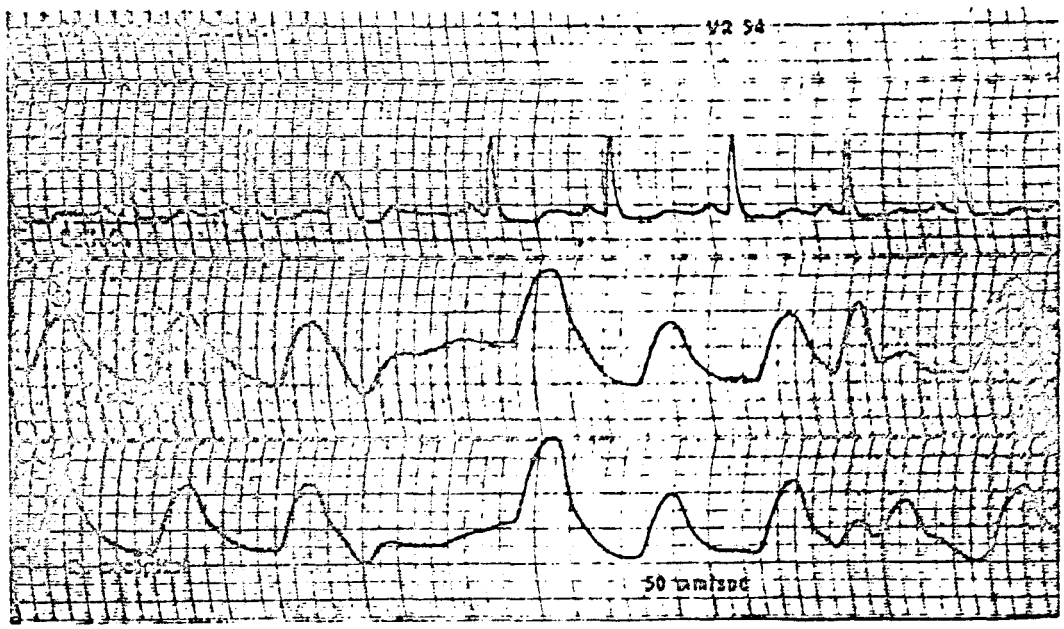

Fig. 16. Regional occipital REG indicates that besides cardiac arrhythmia, there is also a slight atherosclerotic factor in the vertebral-basilar system.

REG examinations are of great value. Cerebral circulation in normal individuals may be disturbed by various factors.

A boy 14 years old, apparently healthy, was examined, and in the course of the examination the amplitude diminished very markedly and moreover became irregular (figure 14). Soon afterwards he began complaining of a severe headache which rapidly increased in intensity. When he began to weep, the examination was interrupted. It was then discovered that he had had no breakfast and his last meal was taken 15 hours ago. He was given warm, heavily sugared tea and a sandwich. Toward the end of the meal the headache began to disappear and the patient soon returned to his normal self. REG was resumed with the same placement of electrodes and identical technical conditions. Respiratory pneumogram showed normalization in rhythm and pattern. ECG was also much less arrhythmic, but the increase in REG amplitude was much slower and the REG lost its irregular pattern only gradually. The patient fell spontaneously asleep, and then full normalization of his REG occurred. We may conclude that the disturbances in cerebral circulation in the form of irregular and diminishing arterial pulsations, with symptoms of violent headache, were a result of alimentary hypoglycemia.

An asymptomatic but very obese volunteer female, 65 years old, demonstrated in November 1963 very marked cardiac arrhythmia with frustrated cardiac systole and sometimes with extrasystole—these irregularities instantaneously affecting the cerebral rheogram (figure 15). These occurred in standard hemispherical and in regional frontal derivations, as well as in regional occipital derivations (figure 16), with slight vascular disturbances atheromatous in character in the vertebral-basilar system. It should be mentioned that this woman was submitted 7 weeks later to an urgent gall bladder operation and died 2 days later in the hospital of a heart attack.

Standard or hemispherical REG does not usually permit us to assess restricted and more localized disturbances in single cerebral

arteries. For more precise evaluation of less intense or smaller cerebral circulatory insufficiency, regional REG may be of considerable value. Simultaneous monitoring of cardiac action with cerebral and ocular pulsations permits us to diagnose circulatory disturbances caused by cardiac and/or vascular factors.

Rheoencephalography may be applied as an additional diagnostic method in the following conditions:

1. Anatomical changes in vessels caused by atherosclerosis, vascular occlusion with thrombosis or embolism, and by aneurysm or arteriovenous malformation.

2. Pathological disorders that are found to be of cardiac or aortic origin.

3. The influences of hemicrania or cerebral circulation.

4. Cerebral edema, as after contusion, and late results of brain injury.

5. Compression of the brain and its vascular supply by extradural, subdural, or intracerebral hematoma, cyst, expanding tumor or by hygroma, an abscess, or accumulation of air.

6. The influence of narcosis, surgical procedures, and various drugs (amyl nitrate, histamine, papaverine, adrenalin, acetylocholine, and others), and oxygen or carbon dioxide.

7. The influence of the sympathetic nervous system, carotid sinus, and of changes in position affecting circulation in the brain.

8. The influence of aura, of focal and generalized epileptic seizures.

9. The consequences of inflammatory and degenerative disorders of the brain.

10. The effect that specific stimulation (for example, acoustic, visual) can have on circulation in the brain.

Rheoencephalography should have standards for instrumentation, technics of application, and interpretation. In future an international agreement on the subject is recommended.

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CHAIRMAN MILLIKAN: Yes, Dr. Wright.

DR. WRIGHT: One question of Dr. Markovich: While I think Dr. Ziemnowicz developed still further the question of electrodes and the importance of standardization, I got the impression that I did not see in Dr. Markovich's presentation any evidence in favor of smaller electrodes, but only evidence in favor of the larger electrodes. Is it true that there is no advantage in smaller, as compared to larger electrodes, and if so, why the arbitary selection of 6 centimeters?

DR. MARKOVICH: There is no arbitrary selection; this is a selection of size by trial. I think that the best we can say is that the size of the electrode should be at least 2½ times larger than the thickness of the combined scalp and skull in the area of the recording.

CHAIRMAN MILLIKAN: Yes, Dr. Barnett.

DR. BARNETT: Dr. Markovich, I would first like to congratulate you on your excellent examination of this problem in a scientific fashion. I would like to ask you to explain what you mean by a unipolar electrode, and I would also appreciate it if you would elaborate on your statement that the position of the indifferent electrode was immaterial. If I understood you correctly, you stated that the position of the indifferent electrode did not influence the measurement.

DR. MARKOVICH: You are partly correct, sir. We are measuring the signal between each active electrode and this indifferent electrode, not between the two active electrodes.

DR. BARNETT: You measured only a signal —.

DR. MARKOVICH: From here to the indifferent.

DR. BARNETT: In other words, you measure from here to here, and the impedance of each of the two current sources to the indifferent electrode is not affected by where you position the indifferent electrode on the scalp?

DR. MARKOVICH: That's right.

DR. BARNETT: I would have assumed that the impedance between the active electrode and any ground or reference point would be related to the distance between the two points, and that therefore the position of the indifferent electrode would be important.

DR. MARKOVICH: This comes from the error of thinking that started in this beautiful monograph of 80 pages by Fritz Jenkner and which tries to condense the experience of 6000 or more patients. The impedance changes that